



**AFRL-ML-WP-TP-2007-499**

## **HYBRIDIZED PHOTOVOLTAIC LIQUID CRYSTAL CELLS AND LIGHT VALVES (PREPRINT)**

**D.R. Evans, G. Cook, J.L. Carns, M.A. Saleh, and N.V. Tabirian**

**Hardened Materials Branch  
Survivability and Sensor Materials Division**

**JANUARY 2006**

**Approved for public release; distribution unlimited.**

*See additional restrictions described on inside pages*

**STINFO COPY**

**AIR FORCE RESEARCH LABORATORY  
MATERIALS AND MANUFACTURING DIRECTORATE  
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433-7750  
AIR FORCE MATERIEL COMMAND  
UNITED STATES AIR FORCE**

## NOTICE AND SIGNATURE PAGE

Using Government drawings, specifications, or other data included in this document for any purpose other than Government procurement does not in any way obligate the U.S. Government. The fact that the Government formulated or supplied the drawings, specifications, or other data does not license the holder or any other person or corporation; or convey any rights or permission to manufacture, use, or sell any patented invention that may relate to them.

This report was cleared for public release by the Air Force Research Laboratory Wright Site (AFRL/WS) Public Affairs Office and is available to the general public, including foreign nationals. Copies may be obtained from the Defense Technical Information Center (DTIC) (<http://www.dtic.mil>).

AFRL-ML-WP-TP-2007-499 HAS BEEN REVIEWED AND IS APPROVED FOR PUBLICATION IN ACCORDANCE WITH ASSIGNED DISTRIBUTION STATEMENT.

\*//Signature//

DEAN R. EVANS, Ph.D.  
Agile Filters Project  
Exploratory Development  
Hardened Materials Branch

//Signature//

MARK S. FORTE, Acting Chief  
Hardened Materials Branch  
Survivability and Sensor Materials Division

//Signature//

TIM J. SCHUMACHER, Chief  
Survivability and Sensor Materials Division

This report is published in the interest of scientific and technical information exchange, and its publication does not constitute the Government's approval or disapproval of its ideas or findings.

\*Disseminated copies will show “//Signature//” stamped or typed above the signature blocks.

<b>REPORT DOCUMENTATION PAGE</b>				<i>Form Approved</i> <i>OMB No. 0704-0188</i>	
The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. <b>PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.</b>					
<b>1. REPORT DATE (DD-MM-YY)</b> January 2006		<b>2. REPORT TYPE</b> Conference Paper Preprint		<b>3. DATES COVERED (From - To)</b>	
<b>4. TITLE AND SUBTITLE</b> HYBRIDIZED PHOTOVOLTAIC LIQUID CRYSTAL CELLS AND LIGHT VALVES (PREPRINT)				<b>5a. CONTRACT NUMBER</b> In-house	
				<b>5b. GRANT NUMBER</b>	
				<b>5c. PROGRAM ELEMENT NUMBER</b> 62102F	
<b>6. AUTHOR(S)</b> D.R. Evans, G. Cook, J.L. Carns, M.A. Saleh, and N.V. Tabirian				<b>5d. PROJECT NUMBER</b> 4348	
				<b>5e. TASK NUMBER</b> RG	
				<b>5f. WORK UNIT NUMBER</b> M08R1000	
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b> Hardened Materials Branch (AFRL/MLPJ) Survivability and Sensor Materials Division Materials and Manufacturing Directorate Wright-Patterson Air Force Base, OH 45433-7750 Air Force Materiel Command, United States Air Force				<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b> AFRL-ML-WP-TP-2007-499	
<b>9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b> Air Force Research Laboratory Materials and Manufacturing Directorate Wright-Patterson Air Force Base, OH 45433-7750 Air Force Materiel Command United States Air Force				<b>10. SPONSORING/MONITORING AGENCY ACRONYM(S)</b> AFRL/MLPJ	
				<b>11. SPONSORING/MONITORING AGENCY REPORT NUMBER(S)</b> AFRL-ML-WP-TP-2007-499	
<b>12. DISTRIBUTION/AVAILABILITY STATEMENT</b> Approved for public release; distribution unlimited.					
<b>13. SUPPLEMENTARY NOTES</b> Conference paper submitted to the Proceedings of the Third International Photorefractive Workshop. This is a work of the U.S. Government and is not subject to copyright protection in the United States. PAO Case Number: AFRL/WS 06-0311, 07 Feb 2006.					
<b>14. ABSTRACT</b> <ul style="list-style-type: none"> <li>Can use PV field in LiNbO3:Fe to activate a liquid crystal</li> <li>This geometry utilizes the photorefractive effect in the substrates (two-beam coupling) and the scattering effect from the liquid crystal</li> <li>A less ionic liquid crystal can be used to correct for effects of screening charges.</li> </ul>					
<b>15. SUBJECT TERMS</b> Liquid Crystal (LC), Holography, Photorefractive, Photovoltaic					
<b>16. SECURITY CLASSIFICATION OF:</b>			<b>17. LIMITATION OF ABSTRACT:</b> SAR	<b>18. NUMBER OF PAGES</b> 12	<b>19a. NAME OF RESPONSIBLE PERSON (Monitor)</b> Dean R. Evans <b>19b. TELEPHONE NUMBER (Include Area Code)</b> N/A
<b>a. REPORT</b> Unclassified	<b>b. ABSTRACT</b> Unclassified	<b>c. THIS PAGE</b> Unclassified			

# Hybridized Photovoltaic Liquid Crystal Cells and Light Valves



J. L. Cams, G. Cook  
M. A. Saleh, D. R. Evans  
Air Force Research Laboratory,  
Materials and Manufacturing Directorate  
Wright-Patterson Air Force Base, Ohio

N. V. Tabirian  
BEAM Engineering for Advanced Measurements Co.  
Winter Park, Florida



## Outline

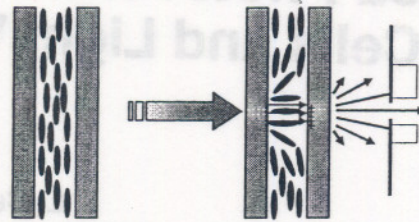


- Motivation
- Nonholographic Hybrid PV Cells
- Nonholographic Hybrid PV Light Valves
- Conclusions





## Motivation



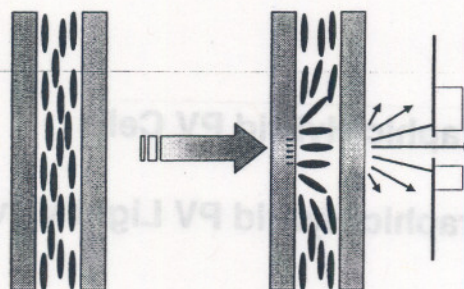
**To develop a self-activated LC cell  
using the photovoltaic effect from  
photorefractive substrates**



## Nonholographic Hybrid PV Cells One Photorefractive Substrate



**Field from one  $\text{LiNbO}_3:\text{Fe}$  substrate  
activates LC**



**Very sensitive to focal position**

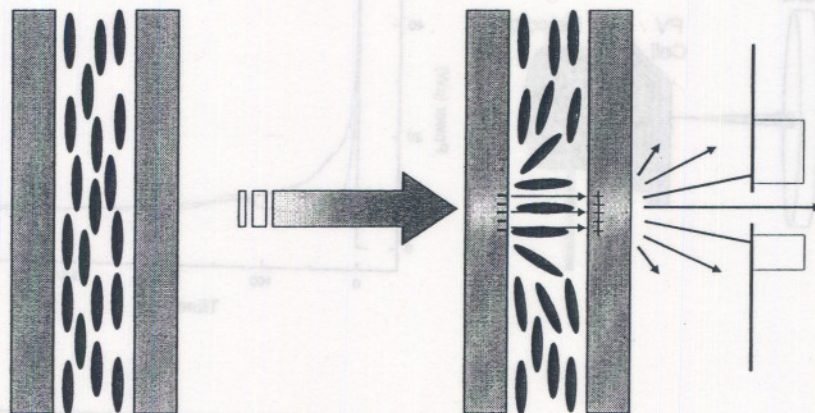




## Nonholographic Hybrid PV Cells Two Photorefractive Substrates



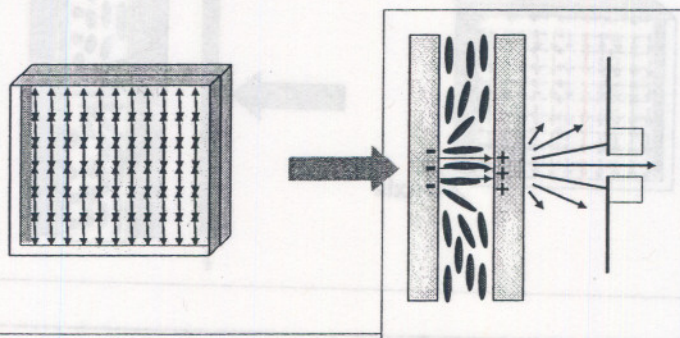
Field between two  $\text{LiNbO}_3:\text{Fe}$  substrates  
activates LC



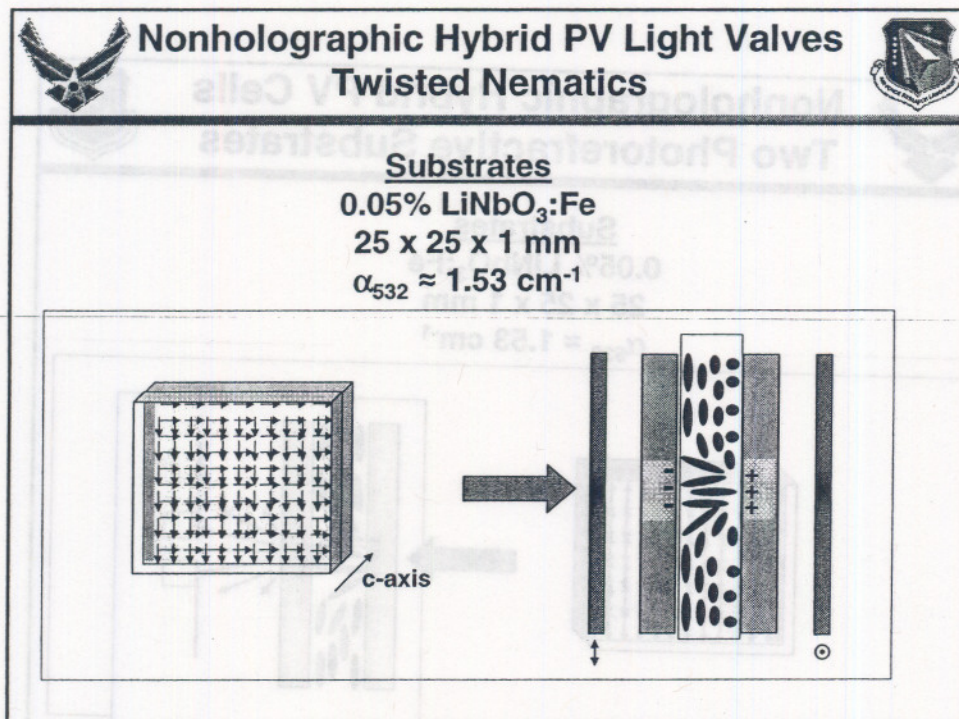
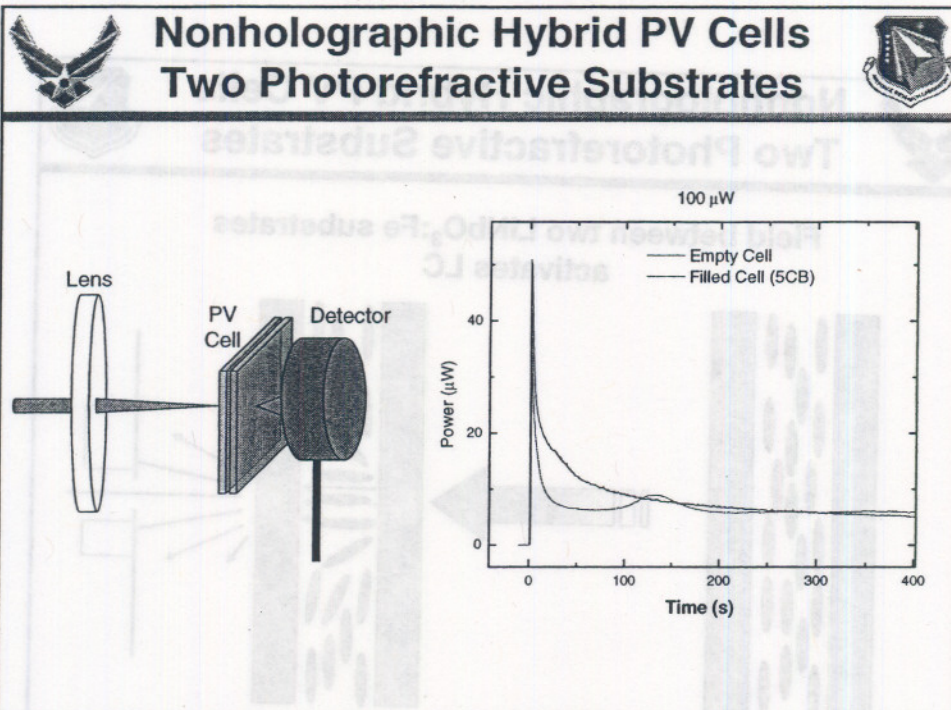
## Nonholographic Hybrid PV Cells Two Photorefractive Substrates



Substrates  
0.05%  $\text{LiNbO}_3:\text{Fe}$   
25 x 25 x 1 mm  
 $\alpha_{532} \approx 1.53 \text{ cm}^{-1}$



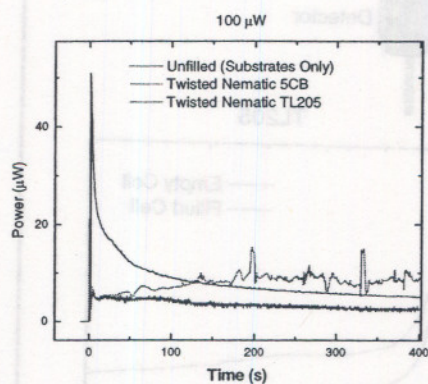






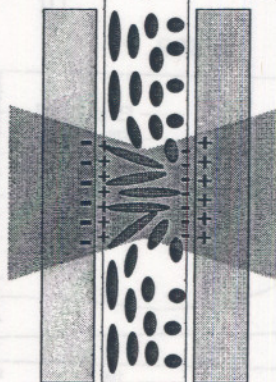


## Nonholographic Hybrid PV Light Valves Twisted Nematics

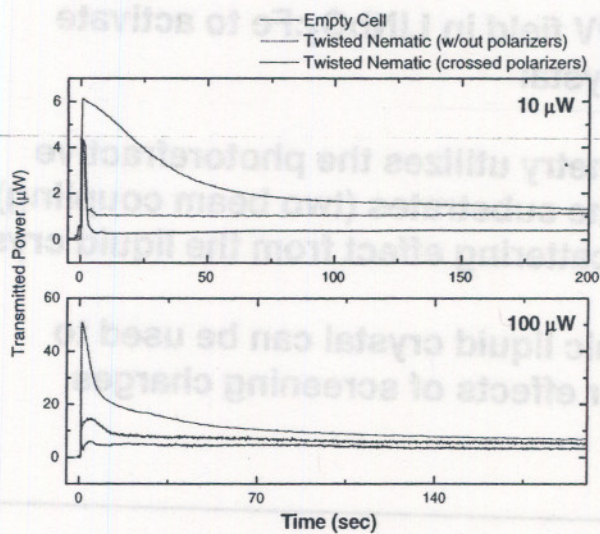


Less ionic LC (TL205) reduces  
buildup of screening charges,  
allowing DOD to increase

### Screening Charges



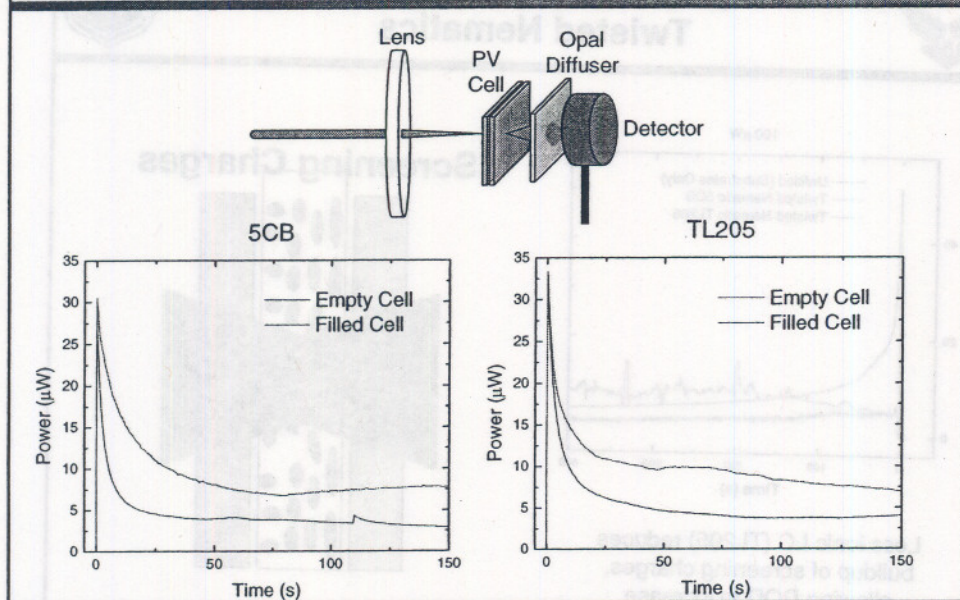
## Nonholographic Hybrid PV Light Valves Twisted Nematics







## Role of the Liquid Crystal



## Conclusions



- Can use PV field in  $\text{LiNbO}_3:\text{Fe}$  to activate a liquid crystal
- This geometry utilizes the photorefractive effect in the substrates (two beam coupling) and the scattering effect from the liquid crystal
- A less ionic liquid crystal can be used to correct for effects of screening charges